

PACKET TUNNELING METHOD IN MOBILE DATA COMMUNICATION NETWORK

BACKGROUND OF THE INVENTION

1. Field of the Invention

5 The present invention relates to the field of mobile communication and, more particularly, to a packet tunneling method in a mobile data communication network.

2. Description of Related Art

10 Recent advances in wireless technologies makes it possible to provide packet data services on mobile communication networks. Besides the traditional circuit-switch voice service, personal communication system is tended to provide packet switch and Internet access services. General packet radio service (GPRS) is one of the example to extend data service over personal communication system.

15 According to the specifications defined in GPRS, mobile stations (MSs) in a public land mobile network (PLMN) can have packet transmitting/receiving capabilities to terminal equipment (TE) connected to a packet data network (PDN) or MSs in another PLMN.

20 FIG. 11 shows the overall architectures and interfaces between nodes of a GPRS network. Packets from TE 902 on a PDN 901 will be routed to Gateway GPRS support node (GGSN) 903 and further transferred to a mobile station (MS) 904 in a PLMN, and packets from MS 904 will be sent to its GGSN via the base station system (BSS) 906 and then routed to a certain TE. To bring up a packet switch call, GPRS
25 defines a number of activation procedures. After accomplishing a set of

signaling procedures, MS 904 or TE 902 can have packet communications to each other.

GPRS provides two service modes to MS, i.e. transparent mode and non-transparent mode. In transparent mode, an MS 904 is given an address belonging to the operator's addressing space. The address can be either statically assigned or be allocated dynamically, but the address should be transparent to hosts out of the PLMN. The unique address will be used for packets routing in a data network. Another operational mode is non-transparent mode. In non-transparent mode, an MS 904 is given a private address belonging to an Intranet or Internet service provider (ISP). The address can be also given either at subscription in which case it is a static address or at connection request as a dynamic address. However, the address is non-transparent to the hosts connecting to the PLMN. Packets to the MS 904 should be first routed to the GGSN 903, replaced its destination address by the private address of the MS 904 at the PLMN, tunneled to Serving GPRS Support Node (SGSN) 905 and then forwarded to the MS 904. In that way, data will have a better protection and the addresses can be reused.

Since the address may reuse in different operators, two MSs with the same static address may register in the same cell and are served by the same SGSN and GGSN. Moreover, a mobile host may roam between SGSNs and may request the in-sequence delivery service, thus a tunneling protocol is needed in a PLMN. GPRS defines a tunneling protocol, called GPRS tunneling protocol (GTP) in their specifications. It defines protocol between GSNs in the GPRS backbone network. It

includes both the GTP signaling and data transfer procedures. GTP allows multi-protocol packets to be tunneled through GPRS backbone. In the signaling plane, GTP specifies a tunnel control and management protocol which allows the SGSN to provide GPRS network access for an MS. In the transmission plane, GTP uses a tunneling mechanism to provide services for carrying user data packets.

However, the use of GTP protocol requires additional GTP header and thus extra processing has to be done. Thus, the transmission performance of the mobile data communication network will be negatively affected. Accordingly, it is desirable to provide an improved packet tunneling method that is able to provide the GTP function without degrading the transmission performance.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a packet tunneling method in a mobile data communication network for avoiding a performance degradation caused by using the tunneling protocol.

To achieve the object, the packet tunneling method first uses a tunneling protocol to set up tunneling information and uniquely identify a tunnel in a signaling procedure. Then, in a data transmission procedure, the method uses information provided by an addressing mechanism of a packet itself to tunnel the packet from one routing node to another with the tunneling information and the uniquely identified tunnel supported in step (A), so as not to use a tunneling protocol in the packet.

Other objects, advantages, and novel features of the invention will become more apparent from the following detailed description when

taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a signaling procedure for activating PDP context;

FIG. 2 shows a PDP context deactivation procedure initiated by
5 MS;

FIG. 3 shows a PDP context deactivation procedure initiated by
SGSN;

FIG. 4 shows a PDP context deactivation procedure initiated by
GGSN;

FIG. 5 shows an example of packet routing from TE to MS
without involving tunneling PDP address;

FIG. 6 shows an example of packet routing from MS to TE
without involving tunneling PDP address;

FIG. 7 shows an inter SGSN packet forwarding without involving
15 tunneling PDP address;

FIG. 8 shows part of a roaming procedure for inter SGSN routing
area update;

FIG. 9 shows an example of packet routing from TE to MS
involving tunneling PDP address;

FIG. 10 shows an inter SGSN packet forwarding involving
20 tunneling PDP address; and

FIG. 11 schematically illustrates the overall architecture and
interfaces between nodes of a GPRS network.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

25 The present invention provides a packet tunneling method in a

mobile data communication network. In general, a tunneling protocol consists of two phases. The first phase, i.e. signaling procedure, is used to set up tunneling information, and associates packet data protocol (PDP) and mobility management (MM) context on routing nodes of a mobile data network with a unique tunnel identifier. The second phase, i.e. data transmission procedure, is used to tunnel packets from one routing node to another by encapsulating the original packets into the tunneling protocol. However, these packets from mobile stations or from hosts outside the mobile data network have their own addressing mechanisms.

10 The packet tunneling method in accordance with the present invention utilizes the information to accomplish the functionality of tunneling protocols, thereby removing the tunneling protocol during transmission phase.

To depict the method of the present invention, a GPRS system and Internet Protocol (IP) based network addressing and routing mechanisms are illustrated for illustrative purpose only.

Because the method of the present invention does not use tunneling protocol in the data transmission procedure, the packet to be transmitted will not have a GTP header, which generally contains the

20 information as listed in the following Table 1.

Table 1

Version	PT	Spare '111'	SNN
Message Type			
Length			
Sequence Number			
Flow Label			
SND CP N-PDU Number			
Spare '1111111'			
Spare '1111111'			
Spare '1111111'			
Tunnel Identifier (8 Bytes)			
.....			

As shown, the GTP header has some important information contained in the fields as follows:

- (1) Length: indicating the size of the packet;
- (2) Sequence Number: used for packet duplication detection, in-sequence delivery and dropping;
- (3) SND CP N-PDU Number: used for GSNs packet forwarding;
- (4) Flow Label: indicating the flow in a tunnel; and
- (5) Tunnel identifier: identifying the unique mobility management (MM) and packet data protocol (PDP) information for a mobile station.

Considering the case that packets from packet data network (PDN) has it own network protocols such as IP and X.25, most of the above functions can be carried out by the protocols, such that the major function of the GTP header can be maintained even though the GTP

header is removed. Herein, IP is used as an example. Table 2 depicts the IP header as follows.

Table 2

Version	Header length
Type of Service	
Length (2 Bytes)	
Identification (2 Bytes)	
3-bit flag	13-bit fragment offset
3-bit flag	13-bit fragment offset
Time to live	
Time to live	
Protocol	
Header checksum (2 Bytes)	
32-bit source IP address	
32-bit destination IP address	

The 16-bit length in IP header can replace the length information in GTP. The 16-bit identification is used to replace the 8-bit sequence number in GTP. Therefore, the length and sequence number information can be carried by the original network protocol.

In the signaling procedure, the method of the present invention creates two extra data items in PDP contexts. The extra information shall be maintained in the GPRS support nodes (GSNs). Combining with the extra information and some original PDP context information can uniquely identify a tunnel. The important routing PDP information stored on the SGSN and GGSN are listed in the following Table 3 and Table 4 respectively.

Table 3

Field	Description
PDP Context Identifier	Index of the PDP context.
PDP State	Packet data protocol state, INACTIVE or ACTIVE.
PDP Type	PDP type, e.g., X.25, PPP or IP.
Tunneling PDP Address Flag	Specifies whether the Tunneling PDP address is used or not.
PDP Address	PDP address, e.g., an X.121 address.
Tunneling PDP Address	Tunneling PDP address, e.g., an X.121 address.
NSAPI	Network layer service address point identifier.
GGSN Address in Use	The IP address of the GGSN currently used.
Send N-PDU Number	SNDCP sequence number of the next downlink N-PDU to be sent to the MS.
Receive N-PDU Number	SNDCP sequence number of the next uplink N-PDU expected from the MS.
SND	GTP sequence number of the next downlink N-PDU to be sent to the MS.
SNU	GTP sequence number of the next uplink N-PDU to be sent to the GGSN.

Table 4

Field	Description
IMSI	International Mobile Subscriber Identity
NSAPI	Network layer service address point identifier.
PDP Type	PDP type, e.g., X.25, PPP or IP.
Tunneling PDP Address Flag	Specifies whether the Tunneling PDP address is used or not.
PDP Address	PDP address, e.g., an X.121 address.
Tunneling PDP Address	Tunneling PDP address, e.g., an X.121 address.
Dynamic Address	Indicates whether PDP address is static or dynamic
SGSN Address	The IP address of the SGSN currently serving this MS.
SND	GTP sequence number of the next downlink N-PDU to be sent to the MS.
SNU	GTP sequence number of the next uplink N-PDU to be sent to the GGSN.

In Table 3, a “Tunneling PDP Address Flag” field and a “Tunneling PDP Address” field are created, such that one of the PDP address and tunneling PDP address is selected based on the value of the tunneling PDP address flag. Similarly, in Table 4, a “Tunneling PDP Address Flag” field and a “Tunneling PDP Address” field are created, and one of the PDP address and tunneling PDP address is selected based on the value of the tunneling PDP address flag.

After creating the two extra data items in PDP contexts, all signaling procedures defined in GTP are remained, and the subsequent procedures can be accomplished successfully, wherein the signaling

procedures are used to set up the mobility management (MM) and packet data protocol (PDP) context on GSNs for packet routing and tunneling. The method of the present invention uses PDP addresses as the unique key to locate MM and PDP context on GSNs instead of tunnel identifier in GTP. If the PDP address is assigned dynamically, GGSN should make sure that the address is unused and can identify a single MM and PDP context of a mobile station. If the PDP address is assigned to a mobile station statically, new connection setup procedures are required.

Assuming that an MS with a static address initiates a packet service, it first requests SGSN with its PDP information. Then, SGSN forwards the requests to GGSN with the PDP information. For GPRS non-transparent mode, PDP addresses can be reused by operators, the requested PDP address may be currently in use by other mobile stations belonging to other operators or ISPs in the same GGSN coverage. In the present invention, once a GGSN gets the request with a static PDP address, it searches in its database. If the address has been used, GGSN will response a new and unused private PDP address to SGSN. The SGSN and GGSN will use this private address as tunneling identifier. That is, the GGSN and SGSN will set the tunneling PDP address flags to 1 for indicating that the data packets will be tunneled by using tunneling address, instead of PDP address, in the packets.

FIG. 1 shows the PDP context activation procedure. Mobile station 101 first initiates an activate PDP context request with a null or a static PDP address, wherein the null PDP address indicates that a dynamic PDP address is requested. Once SGSN 102 gets the activate

PDP context request from the mobile station 101, it forwards the request to GGSN 103. If addresses are dynamically assigned, GGSN 103 will response an unused PDP address to SGSN 102 and MS 101. The PDP address will be used as the tunnel identifier. If a static PDP address is requested, GGSN 103 should consider a situation that the PDP address has been used by other MS. In case that the PDP address has not been used, GGSN 103 will response the PDP address to SGSN 102 and MS 101 for being used as the tunnel identifier. In case that the PDP address has been used, the requested PDP address is still maintained in the SGSN 102 and GGSN 103, but a unique tunneling address is allocated as tunnel identifier between GGSN 102 and SGSN 103.

The established connection as described above can be closed at the end of communication. FIGS. 2, 3 and 4 depict three different situations of closing connections initiated by MS 101, SGSN 102, and GGSN103, respectively, so as to release the tunneling address.

Once a unique PDP address or tunneling PDP address is assigned for packet tunneling, the data transmission procedure, i.e. the packet routing and tunneling, within a PLMN can be realized without GTP. FIG. 5 shows an example of packets routing from terminal equipment (TE) 104 outside the PLMN to an MS 101. In non-transparent mode, the GGSN address is published to outside hosts, and such a public GGSN address is denoted by PGIP. Data communication to MSs can perform address translation on GGSN. GGSN can apply network address translator (NAT) technique or etc. to solve the address translation problem. Packets 105 from TE 104 are routed to the GGSN 103 where

the MS 101 locates. Then, the packets 105 are processed by GGSN 103. The destination of the original packet 105 (i.e., the public GGSN address PGIP) will be replaced by the private PDP address of the MS 101 (denoted by VMIP). After that, GGSN 103 encapsulates the received
5 packets 105 in IP protocol where the source address is the private address of the GGSN 103 (denoted by VGIP) and the destination is the private address of the SGSN 102 (denoted by VSIP). The routing information can be resolved by PDP and MM contexts on GSNs. After SGSN 102 picks up the packets 105, it realizes the packet 105 carries another IP
10 packet from its header. For example, the packet 105 can be identified in the protocol type field of an IP header. SGSN 102 opens the packets, decodes the destination PDP address, and searches PDP context on SGSN database based on its PDP address. Then, SGSN 102 can resolve the routing for the packets. FIG. 6 shows the reversed direction where
15 packets are sent from MSs to outside TEs.

Because the mobile station may be freely moved in the PLMN, the packet transmission must consider the roaming of the mobile station. With reference to FIG. 7, there is shown a situation of inter SGSN packet forwarding without involving tunneling PDP address, wherein an MS
20 101 is roaming from a base station system (BSS) 106 to another one 107 in the same GGSN. Before the MS 101 completely roams to the new SGSN 108, some packets may route to old SGSN 102. These packets must be forwarded to the new SGSN 108 by the old SGSN 102. The private PDP address of the mobile station (VMIP) still can be used as the
25 unique identifier. The old SGSN 102 replaces the destination address of

the routing protocol (i.e., the private address of the original SGSN 102, denoted by VSIP1) with the new SGSN private address (denoted by VSIP2) and forwards the packets 105 to the new SGSN 108. However, the SMDCP protocol employed in BSS networks needs a sequential
5 number to control the packet delivery, the new SGSN 108 can not resolve this number if the sequence number and SMDCP number are eliminated in GTP header. To inform the new SGSN 108 the start number in SMDCP packets of consecutive packets, two new parameters are inserted for roaming signaling procedures. With reference to FIG. 8, there is shown
10 part of the inter SGSN routing area update procedure. As shown, when the MS 101 sends a routing area update request to the new SGSN 108 due to roaming, the new SGSN 108 issues a SGSN context request, and the old SGSN 102 responses a SGSN context response with its sending N-PDU number and receiving N-PDU number. In that way, the new SGSN
15 108 can use these two parameters to initial SMDCP protocol stack in the new SGSN 108, so as to control the packet transmission.

If an MS has a static PDP address and the PDP address has been used in the PLMN, a tunneling PDP address shall be allocated. The tunneling PDP address is only for tunneling between GSNs. The
20 mapping between tunneling addresses and MSs address should be transparent to MSs. With reference to FIG. 9, there is shown a situation of packet routing from TE 104 to MS 101 involving tunneling PDP address. Packets 105 routing from TE 104 to GGSN 103 remain unchanged. GGSN 103 gets the PDP information and finds that the tunnel address is
25 enabled. After checking a PDP context table 111, GGSN 103 replaces the

destination PDP address (the public GGSN address, PGIP) by the tunneling PDP address (MS's tunneling PDP address, TMIP1) and transmits the packets 105 to SGSN 102. SGSN 102 gets the packet 105, and finds the PDP information by the tunneling PDP address (MS's tunneling PDP address, TMIP1). After checking a PDP context table 112, SGSN 102 replaces tunneling address (MS's tunneling PDP address, TMIP1) by MS's real PDP address (VMIP), and forwards the packets 105 to the MS 101.

As to the packet transmission when the mobile station is roaming, with reference to FIG. 7, there is shown a situation of inter SGSN packet forwarding involving tunneling PDP address, wherein an MS 101 is roaming from a base station system (BSS) 106 to another one 107 in the same GGSN .

FIG. 10 shows the situation while the tunnel address is used during inter SGSN roaming, wherein packets are forwarded from SGSN 102 to another SGSN 108. The procedures are similar to the one in FIG. 7. The only difference is that the replacement of the tunnel address (MS's tunneling PDP address, TMIP1) to real MS's PDP address (VMIP) is performed by the new SGSN 108.

In addition, although the flow identifier, used to distinguish flows aggregate in the same tunnel, in the GTP header has been eliminated, the signaling flow can still have its unique flow identifier since the invention does not remove the signaling formats and signaling procedures. As for the transmission of data packets, the flows in the same channel can be separated by PDP information in GSNs, so as not to cause any problems

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	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024	2024-2025	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036	2036-2037	2037-2038	2038-2039	2039-2040	2040-2041	2041-2042	2042-2043	2043-2044	2044-2045	2045-2046	2046-2047	2047-2048	2048-2049	2049-2050	2050-2051	2051-2052	2052-2053	2053-2054	2054-2055	2055-2056	2056-2057	2057-2058	2058-2059	2059-2060	2060-2061	2061-2062	2062-2063	2063-2064	2064-2065	2065-2066	2066-2067	2067-2068	2068-2069	2069-2070	2070-2071	2071-2072	2072-2073	2073-2074	2074-2075	2075-2076	2076-2077	2077-2078	2078-2079	2079-2080	2080-2081	2081-2082	2082-2083	2083-2084	2084-2085	2085-2086	2086-2087	2087-2088	2088-2089	2089-2090	2090-2091	2091-2092	2092-2093	2093-2094	2094-2095	2095-2096	2096-2097	2097-2098	2098-2099	2099-2100	2100-2101	2101-2102	2102-2103	2103-2104	2104-2105	2105-2106	2106-2107	2107-2108	2108-2109	2109-2110	2110-2111	2111-2112	2112-2113	2113-2114	2114-2115	2115-2116	2116-2117	2117-2118	2118-2119	2119-2120	2120-2121	2121-2122	2122-2123	2123-2124	2124-2125	2125-2126	2126-2127	2127-2128	2128-2129	2129-2130	2130-2131	2131-2132	2132-2133	2133-2134	2134-2135	2135-2136	2136-2137	2137-2138	2138-2139	2139-2140	2140-2141	2141-2142	2142-2143	2143-2144	2144-2145	2145-2146	2146-2147	2147-2148	2148-2149	2149-2150	2150-2151	2151-2152	2152-2153	2153-2154	2154-2155	2155-2156	2156-2157	2157-2158	2158-2159	2159-2160	2160-2161	2161-2162	2162-2163	2163-2164	2164-2165	2165-2166	2166-2167	2167-2168	2168-2169	2169-2170	2170-2171	2171-2172	2172-2173	2173-2174	2174-2175	2175-2176	2176-2177	2177-2178	2178-2179	2179-2180	2180-2181	2181-2182	2182-2183	2183-2184	2184-2185	2185-2186	2186-2187	2187-2188	2188-2189	2189-2190	2190-2191	2191-2192	2192-2193	2193-2194	2194-2195	2195-2196	2196-2197	2197-2198	2198-2199	2199-2200	2200-2201	2201-2202	2202-2203	2203-2204	2204-2205	2205-2206	2206-2207	2207-2208	2208-2209	2209-2210	2210-2211	2211-2212	2212-2213	2213-2214	2214-2215	2215-2216	2216-2217	2217-2218	2218-2219	2219-2220	2220-2221	2221-2222	2222-2223	2223-2224	2224-2225	2225-2226	2226-2227	2227-2228	2228-2229	2229-2230	2230-2231	2231-2232	2232-2233	2233-2234	2234-2235	2235-2236	2236-2237	2237-2238	2238-2239	2239-2240	2240-2241	2241-2242	2242-2243	2243-2244	2244-2245	2245-2246	2246-2247	2247-2248	2248-2249	2249-2250	2250-2251	2251-2252	2252-2253	2253-2254	2254-2255	2255-2256	2256-2257	2257-2258	2258-2259	2259-2260	2260-2261	2261-2262
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